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Interest and Confusion: Contrasting Theoretical Approaches

RESEARCH

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ABSTRACT

Epistemic emotions, in particular interest and confusion, are central to the development of knowledge. Past research suggests that interest and confusion depend on specific cognitive appraisals, although different theoretical models coexist. Here we compared the appraisal structure for interest and confusion elicited by metaphorical sentences. We hypothesized that 1) metaphorical sentences would elicit more interest and/or confusion compared to literal sentences and 2) that novelty, complexity and value appraisals would positively predict interest and confusion, while coping potential would positively predict interest, but negatively predict confusion. We further hypothesized that hunger would be related to enhanced emotions. Metaphors did not significantly elicit more interest and confusion than literal sentences. Results however revealed the importance of the appraisals of novelty, value and coping potential for both interest and confusion, while complexity was only related to confusion. Finally, the more participants were hungry, the more they reported intense emotions. Results are discussed in regard to several coexisting appraisal models of epistemic emotions.

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1. INTRODUCTION

Epistemic emotions, or "knowledge emotions" (Silvia, 2010), are defined as "emotions that are caused by cognitive qualities of task information and the processing of that information" (Muis, 2015, p. 169). Epistemic emotions typically arise during learning and are elicited by one's beliefs regarding one's thoughts and knowledge (Silvia, 2010). Muis and colleagues (Muis, Pekrun et al., 2015) suggest that epistemic emotions depend on the evaluation of the (mis)alignment between new information and prior knowledge, beliefs or information. Positive epistemic emotions may arise when consistencies between prior knowledge and new information or content are noticed (Muis et al., 2018). For example, if people face new information that is consistent with their previous knowledge, they will experience epistemic joy. In contrast, negative epistemic emotions may arise when the learner face discrepancies or inconsistencies, which may lead to cognitive disequilibrium (D'Mello, Lehman et al., 2014).

Epistemic emotions include interest, anxiety, frustration, surprise, boredom, enjoyment and confusion (Pekrun et al., 2017). These emotions have recently been studied through the appraisal theories framework (e.g., Chevrier et al., 2019; Pekrun et al., 2017). Appraisal theorists suggest that individuals react to the environment they live in. More specifically, they suggest that when they face an event, individuals first assess how relevant this event is for them. Then, the event is appraised on several dimensions, also called "cognitive appraisals", which are at the root of any emotion. Appraisals are the source of emotions and constitute emotional experiences (Lazarus, 1991; Scherer, 2001). The combination of specific appraisals results in specific emotions. As suggested by Kuppens and Tong (2010), people can differ in their emotional experiences in 1) how they appraise the circumstances of emotional experiences and 2) in the quality of experienced emotions that are associated with specific patterns of appraisal outcomes.

Here, we are specifically interested in two epistemic emotions, namely interest and confusion. Interest is defined as an emotion that motivates learning, exploration, intrinsic motivation and information seeking (Silvia, 2008). Confusion is defined as "a metacognitive signal: it informs people that they do not comprehend what is happening and that some shift in action is thus needed, such as a new learning strategy, more effort, or withdrawal and avoidance" (Silvia, 2009, p. 50). In this experiment, we specifically focus on confusion and interest, because they are supposed to share a common appraisal dimension (Silvia, 2010), although new evidence suggest that other appraisals may be of importance (e.g., Connelly, 2011; Muis et al., 2018).

Silvia suggests that interest and confusion are related to a specific appraisal structure (Silvia, 2010). The first appraisal is "novelty-complexity" and the second is "coping potential" (Silvia, 2005, 2008, 2010). The novelty-complexity appraisal refers to the evaluation of whether an event is new, sudden or unfamiliar (see Scherer, 2001). The appraisal of coping potential refers to one's perceived ability to face an event (Scherer, 2001). Silvia proposes that interest and confusion both arise when a person faces something new, unfamiliar and complex – i.e., a "novelty-complexity" dimension (Silvia, 2005). Interest arises when individuals consider they can understand the event or information they are facing (see for example Fayn et al., 2017). In contrast, when they feel the event is poorly comprehensible, they should feel confusion (Silvia, 2010). This refers to coping potential (Silvia, 2005).

Connelly's (2011) model is deeply anchored in Silvia's model. Indeed, as for Silvia's model, Connelly suggests that novelty-complexity and coping potential are relevant appraisals for interest. Connelly (2011) suggests that this model could be improved by adding one supplementary appraisal to predict interest: goal relevance. This appraisal is defined as "an evaluation of an event's personal importance based upon a review of one's concerns and what one considers important relative to other events" (Connelly, 2011, p. 625). This appraisal may be related to "motivational relevance". In his study, Connelly reveals that goal relevance significantly and positively predicted interest in addition to novelty-complexity and coping potential appraisals (Connelly, 2011).

The last theoretical model we focus on is the one proposed by Muis and colleagues (2018). These authors do not focus only on interest and confusion but propose a model for epistemic emotions. Notably, they suggest that epistemic emotions arise from information-oriented appraisals. In that sense, appraisals assess the (mis) alignment between new and prior information or beliefs. Muis et al. (2018) thus propose a five-appraisals model as direct antecedents of epistemic emotions, which can be applied to interest and confusion. These appraisals are control, value, novelty, complexity and achievement of an epistemic aim. Control may be oriented toward actions or outcomes. In the first case, control refers to the appraisal that individuals feel that are able to carry the task – i.e., provide justifications or weigh multiple perspectives, while in the second case, it refers to the perception that individuals' have regarding their capacity to understand the content (Muis et al., 2018). Value taps into the subjective importance granted to 1) the understanding of the content and 2) the achievement of an epistemic aim (Muis et al., 2018). As an example, if a learner feels low in control but high in value, they may feel epistemic anxiety. If a learner feels that their prior knowledge is consistent with a proposition (high control) and that they value this activity, they will experience epistemic joy. In contrast, if both control and value are low, epistemic boredom may arise.

Beside control and value appraisals, Muis and colleagues (2018) define novelty as an important appraisal of epistemic emotions. Novelty refers to the fact that

individuals may perceive the information as new, novel or unique (Muis et al., 2018). Novelty may trigger epistemic emotions when information is new or unexpected, when it is inconsistent with prior knowledge or newly "received" information or when it is in contrast with one's epistemic belief (Chevrier et al., 2019 in Muis et al., 2018). Complexity refers to how people assess the complexity of the information they face. As D'Mello et al. (2014) highlight, complexity is key in complex learning tasks. Complex learning refers to the comprehension of difficult texts, the resolution of mathematical problems or the modeling of complex systems. In such case, learners have to engage in complex mental tasks such as inferences, causal question answering and problem solving. Complexity of a task or information may trigger epistemic emotions such as surprise, confusion, or anxiety, depending on whether this task or information is also new (Muis et al., 2018). The last appraisal of the model is defined as the achievement of an epistemic aim. This appraisal refers to whether the epistemic aim that the learner has is reached or not. More specifically, learners set goals for their learning, and the information they face is evaluated in terms of how it favors or impedes the achievement of epistemic goals. For example, a student may set an epistemic aim as the ability to understand a complex problem. If they feel they are able to solve this problem, then they may feel joy as an epistemic emotion related to the achievement of this epistemic aim. In contrast, if they feel stuck and not able to reach their goal, they may experience epistemic confusion, frustration or anxiety.

Here we compare Silvia's (2010), Connelly's (2011) and Muis and colleagues' (2018) appraisals models. As Silvia (2010) and Connelly's (2011) models do not focus on all epistemic emotions, we here test the appraisal models for interest and confusion only. As highlighted in the descriptions of the three models above, some appraisals share similarities (see Table 1 for a systematic comparison): while Silvia talks about "coping potential", Muis and colleagues refer to "control"; Silvia's, Connelly's and Muis' frameworks refer to novelty as well as complexity. Muis and colleagues mention "value", which can be considered as close to what Connelly (2011) defines as "goal relevance".

SILVIA (2005)	CONNELLY (2011)	MUIS (2018)
Novelty-complexity	Novelty-complexity	Novelty
		Complexity
Coping potential	Coping potential	Control
	Goal relevance	Value
		Achievement of epistemic aim

Table 1 Description of appraisals as proximal antecedents of Interest/Confusion based on 1) Silvia (2005), 3) Connelly (2011) and 3) Muis (2018).

To compare these theories, we chose metaphors. Linguistic metaphors "describe a topic of discussion in terms of a semantically unrelated domain" (Thibodeau et al., 2017, p. 852). Recent evidence highlights that metaphors may shape how people think and behave (see Thibodeau et al., 2017 for a review). Several studies suggest that metaphorical sentences have a stronger emotional impact than their literal counterparts (Aziz-Zadeh & Gamez-Djokic, 2016; Citron & Goldberg, 2014; Mohammad et al., 2016), while they encourage for more research on the potential impact of metaphors on emotion processing (Aziz-Zadeh & Gamez-Djokic, 2016).

However, to the best of our knowledge, no previous studies have measured how interest and confusion can be induced by metaphors. We hypothesize that 1) metaphorical sentences may increase interest and/or confusion compared to their literal sentences and 2) that novelty, complexity and value would positively predict interest and confusion, while coping potential would positively predict interest, but negatively predict confusion.

More specifically, we chose to use food-related metaphors. Evidence suggests that hunger can modulate several cognitive processes (see Benau et al., 2014), such as attention (e.g., Hardman et al., 2021; Piech et al., 2010) and memory for food stimuli (e.g., Montagrin et al., 2019). In the verbal domain, Epstein and Levitt (1962) showed that learning and recall of food-related words were increased by hunger. This evidence is congruent with appraisal theories of emotion (see Sander et al., 2005), which suggest that relevant stimuli for one's needs, goals and/or values are related to higher emotional intensities. When considering stimuli related to food, we hypothesize (hypothesis 3) that the items will be related to enhanced emotions when one is hungry.

2. METHOD

2.1. PARTICIPANTS

121 participants (mean age = 36.06 ± 12.87 years) were invited to participate to this experiment (94 females). The majority of them had completed a university degree – either bachelor, master or doctoral degree (n = 67, 55.38%). The study was approved by the ethical committees of the Psychology Department of UniDistance Suisse. Participants completed an online survey and were paid 40 Swiss Francs (approximately 40 US dollars) for their participation. When starting the experiment, participants were first asked to give their consent to participate to the study. We defined our sample size estimation based on Arend & Schäfer's (2019) rule of thumb, who suggested that cross-level interaction effects can be detected from any combination between 200 participants with 9 items and 125 participants with 25 items at a power of .80. As we measured 22 items for each participant in each condition (see below), we recruited 125 participants. We collected usable data from 121 participants.

2.2. MATERIALS AND PROCEDURE

Metaphorical sentences were adapted from Citron and Zervos (2018) and Citron and Goldberg (2014). 44 sentences (22 metaphorical, e.g., "she gazed at him sweetly" – 22 literals, e.g., "she gazed at him cutely"; see Audrin & Coppin, 2022) were presented using Limesurvey. There was no significant difference between metaphorical and literal sentences for imageability ($F(1,21) = 0.05$, $p = .822$), emotional valence ($F(1,21) = 1.89$, $p = .183$) and emotional arousal ($F(1,21) = 3.45$, $p = .078$) (Audrin & Coppin, 2022). Participants were then asked to rate how interested and confused they were when reading each sentence. Moreover, after each metaphorical sentence we measured participants' appraisals of complexity ("how complex is this sentence"), novelty ("how familiar is this sentence"), control ("how easy this sentence is to understand"), and value ("how important this sentence is"). We did not measure participants' achievement of the epistemic aim, as they were not aware that they would have to recall the sentences. All emotions and appraisals were measured on a Likert scale ranging from 1 (not at all) to 7 (extremely). The experiment was conducted in German.

2.3. DATA ANALYSIS

Analyses were performed using R (R Development Core Team, 2008), lmerTest (Kuznetsova et al., 2017), lme4 (Bates et al., 2015), BRMS (Bürkner, 2018; Bürkner et al., 2022) and visreg packages (Breheny & Burchett, 2017). We performed linear mixed model analyses on the ratings of emotions reported by participants to estimate between-person and within-person effects. We introduced participants and stimuli as random intercepts. Condition (metaphorical vs. literal) was introduced as a random slope for items. Moreover, emotions (interest vs. confusion) were integrated as random slopes for both items and participants. Emotions and Condition were further introduced as fixed effects, along with the appraisals and hunger. To test the impact of appraisals on each specific emotions, we assigned the coding 0/1 to the "emotions" factor. In Table 2 below, we report the main effects for the fixed effects. We further computed the Bayes Factors associated with each fixed effect tested in the model. To do this, we used weakly informative priors for the random effects. which is the default informative proposed in the BRMS package – i.e., a t-distribution with DF = 3, center on 0 and a scale of 5. We set the priors for the fixed effects coefficients to a normal prior centered on 0 and with a scale of 1. We used 4 Markov chains with 1000 warm-up iterations and 5000 regular iterations.

3. RESULTS

Results of the analyses performed to test the effect of appraisals, hunger, condition and type of emotions on the intensity of emotions are presented in Table 2.

RANDOM EFFECTS	VARIANCE	STD.DEV	CORRELATION				
ID	.311	.56					
Emotion	.15	.39	–.44				
Stimuli	.09	.32					
Condition	.008	.08	.63				
Emotion	.25	.50	.66	.20			
FIXED EFFECTS	**SUM SQ**	**MEAN SQ**	**NUMDF**	**DENDF**	**F VALUE**	**PR(>F)**	**BF**
Emotion	7.05	7.05	1	37	4.28	.05	572.41
Complexity	276.85	276.85	1	10233	168.19	.001	>1000
Novelty	83.94	83.94	1	9830	50.99	.001	>1000
Value	1966.44	1966.44	1	9736	1194.64	.001	>1000
Coping Potential	8.73	8.73	1	9530	5.30	.02	.137
Condition	0.02	0.02	1	22	0.01	.91	. 013
Hunger	9.90	9.90	1	119	6.01	.02	.417
Emotion*Complexity	253.75	253.75	1	9310	154.16	.001	>1000
Emotion*Novelty	4.40	4.40	1	9366	2.67	.10	. 033
Emotion*Value	292.07	292.07	1	9384	177.44	.001	>1000
Emotion*Coping Potential	194.38	194.38	1	7512	118.09	.001	>1000
Emotion*Condition	4.51	4.51	1	10375	2.74	.10	.026

Table 2 Multilevel analyses results for the intensity of interest and confusion.

Note: Variance (τ) and standard deviation (ρ) are reported for random intercepts for participants and items as well as random slopes by emotion per participants and condition and emotions by items.

Contrary to hypothesis 1, there was no significant effect of the condition (b = .02, *95%CI* = [–.04;.07], t = .56, p = .572), suggesting that metaphorical sentences did not significantly enhance emotions, when compared to literal sentences.

Regarding the prediction of interest, our results reveal a significant positive effect of novelty (b = .08, *95%CI* = [.06;.10], t = 5.50, p < .001), value (b = .40, *95%CI* = [34;.42], t = 29.58, p < .001) and coping potential (b = .15, *95%CI* = [.09;.14], t = 11.32, p < .001). These results partially support our second hypothesis as the more participants felt the stimulus was new, relevant and that they could manage it, the more they felt interested toward it.

Regarding the prediction of confusion, our results reveal a significant positive effect of complexity (b = .32, *95%CI* = [.30;.37], t = 18.54, p < .001), novelty (b = .07, *95%CI* = [.04;.10], t = 4.59, p < .001), value (b = .25, *95% CI* = [.24;.39], t = 18.62, p < .001) and a negative impact of coping potential (b = –.11, *95%CI* = [.09;.14], t = –8.73, p < .001). These results support our second hypothesis as the more participants felt the stimulus was complex, new, relevant but they felt that they may not manage it, the more they felt confusion toward it. Results are depicted in Figure 1 below. Globally, these results highlight that the impact of complexity (b = –.16, *95%CI* = [–.20; –.16], t = –14.80, p < .001), value (b = .07, *95%CI* = [.04;.08], t = 6.30, p < .001) and coping potential (b = .13, *95%CI* = [.12;.15], t = 14.57, p < .001) were different for interest and confusion.

Finally, our results confirm our third hypothesis: the more participants were hungry, the more they reported intense emotions (b = .06, *95%CI* = [.02;.09], t = 2.45, p = .01).

4. DISCUSSION

In this article, we tested how 1) metaphorical sentences dealing with food are related to enhanced interest and/or confusion compared to literal sentences, 2) appraisals of complexity, novelty, value and coping potential predict interest and confusion, and 3) hunger increases the intensity of emotional response toward food-related stimuli.

Our results show that the more participants were hungry, the more they reported intense emotions. These results are consistent with previous findings suggesting that hunger could impact the intensity of emotional responses (e.g., Ackermans et al., 2022; MacCormack & Lindquist, 2019). However, we could not find any evidence that metaphorical sentences were more related to enhanced interest nor confusion than their literal counterparts. This result complements previous literature which suggests that metaphors are more emotional than literal sentences. The lack of effect may be due to 1) the fact that we only measured emotions related to the epistemic aspect of the sentences (interest and confusion) and 2) that we used self-reported scales, while previous studies (e.g., Citron & Goldberg, 2014) recorded other measures of emotionality. Future studies

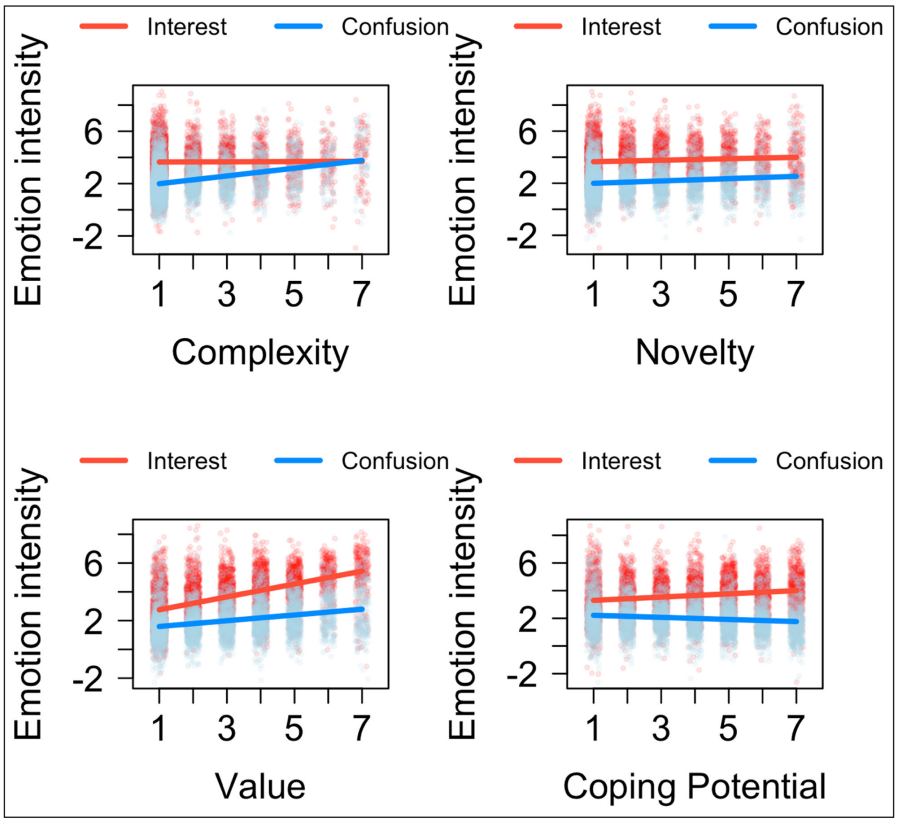

Figure 1 Graphical representation of the effect of Complexity, Novelty, Value and Coping potential on the intensity of Interest and Confusion.

should consequently measure a large spectrum of emotions, and record several measures of emotionality to further address this question.

Results partially support out second hypothesis: novelty, value and coping potential significantly and positively predicted interest. However, complexity did not reach significance. This contrasts with previous findings (Connelly, 2011; Silvia, 2008), although one study suggested that interest may be more complex and that its structure may be more varied (Dukes et al., in prep.). In contrast, our hypotheses are fully supported for confusion: complexity, novelty and value significantly and positively predicted confusion, while coping potential was negatively related to confusion. Globally, these results support previous models predicting interest and confusion. Although complexity did not significantly predict interest in our case, all other appraisals predicted interest and confusion, just as suggested by Silvia (2008), Connelly (2011) and Muis and colleagues (2018). We did not test the last appraisal of Muis and colleagues' framework (i.e., the impact of epistemic goal achievement or impasse) as participants could not have set any epistemic goals in our precise context. However, Chevrier et al. (2019) suggested that this appraisal has a low predictive power in epistemic emotions.

The current findings support previous theoretical models of appraisals of confusion and interest, and reveal that novelty, complexity, value and coping potential are related to interest and confusion in metaphorical and literal sentences. This result provides strong support to Connelly's model (2011) and partial support for Muis and colleagues' model (although we did not test their last proposed appraisal). We cannot conclude on the impact of metaphorical sentences on interest and confusion, but advocate for further research on the emotionality embedded with metaphors (e.g., Citron & Goldberg, 2014; Citron & Zervos, 2018).

AUTHORSHIP RESPONSIBILITY

The submission is a truthful, original work without fabrication, fraud or plagiarism, and contains no libelous or unlawful statements. It has not been published previously except in abstract form. Each author has participated sufficiently in the work to take responsibility for its truthfulness and validity and has read the complete manuscript. The original data are available at https://osf.io/kh2j4.

TRANSPARENCY STATEMENT

We reported how we determined the sample size and the stopping criterion. We reported all experimental conditions and variables. We report all data exclusion criteria and whether these were determined before or during the data analysis. We report all outlier criteria and whether these were determined before or during data analysis.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

CA and GC designed the study. CA programmed the experiment and run analyses. CA and GC interpreted the data and wrote the manuscript.

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